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EVALUATION OF SEVERAL EXPERIMENTAL AVIATION SELECTION TESTS

James R. Berkshire



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EVALUATION OF SEVERAL EXPERIMENTAL AVIATION SELECTION TESTS

James R. Berkshire

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NAVAL AEROSPACE MEDICAL INSTITUTE NAVAL AEROSPACE MEDICAL CENTER PENSACOLA, FLORIDA

SUMMARY PAGE

THE PROBLEM

The tests currently available for the selection of men to be trained as naval aviators leave room for improvement. This is a study to determine whether any of several experimental tests might add significantly to the validity of the present battery.

FINDINGS

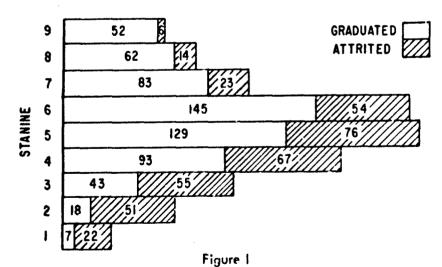
A short-form of the Instrument Comprehension test and the more valid items of the Background test appear to merit revalidation under actual selection conditions. One or two of the scores from the Prestige/Security scale may add to the validity of secondary selection formulac, i.e. those used to estimate the probable success of students who are already in training.

INTRODUCTION

This report describes efforts to develop several new tests that might add to the validity of the battery used to select naval aviators. The current battery includes a general intelligence test, the Aviation Qualification Test (AQT), which, while mainly verbal-numerical, also contains some items that measure clerical accuracy. Scores on this test relate to performance in academic subjects, usually with correlations of about .60 in unrestricted samples. The balance of the battery includes two tests, the Mechanical Comprehensior. Test (MCT) and the Spatial Apperception Test (SAT), that discriminate between potential flight failures and successes, and a third test, the Biographical Inventory (BI), that has a useful predictive relationship to voluntary withdrawal from the flight training program. Scores from these latter three tests make up a composite "Flight Aptitude Rating" (FAR) which is expressed in stanine scores. In an unrestricted sample these scores usually have a correlation of .40 to .50 (biserial) with a dichotomous, completed/dropped criterion.

Figure I shows the relationship of the FAR battery scores to success in flight training. It can be seen that even in the two highest stanine groups, about 15 per cent of the selectees failed to complete the program. It was reasoned that if there were flight training failures among this 15 per cent, an examination of the causes of their failures might reveal areas of flying ability not now covered by the tests.

Twenty such persons were found, and the comments made about their flying by the flight instructors were examined. Two comments occurred sufficiently often to be provocative: The first described a persistent pattern of landing too high or too low, an apparent inability to judge the height of the plane in relation to the runway; the second dealt with the students being unable to proceed correctly through the sequence of actions required to complete a maneuver.



Relationship of FAR Scores to Success in Flight Training

EXPERIMENTAL TESTS

Two tests hopefully intended to measure these abilities were devised, "Altitude Judgment" and the "Maneuvers Test." For the Altitude Judgment test a large number of 35-mm photographs of the runway were taken through the windshield as a plane was coming in for a landing. They were taken at various points in the descent and with the plane in varying aititudes and positions relative to the landing strip. From the finished slides reproducible drawings were made by projecting the slides on a glass screen and tracing them on translucent paper. A selection of these was made for the test, a portion of which is shown in Appendix A.

The "Maneuvers Test" described the operating characteristics of a hypothetical, simplified airplane. It then asked the subject to specify the sequence of throttle, rpm, and stick positions necessary to complete a series of maneuvers. These included "take-off," "climbing turn," "figure eight," "Immelman," "power-on glide," "field entry," and "landing." The correct answer might require as many as twelve steps which had to be in correct sequence. While a trial run of this test indicated some validity, the test was too difficult and the original scoring methods were unsatisfactory for general use. Efforts are current to develop a more practical version of the test.

A third test was developed by choosing from the sixty-item Instrument Comprehension Test used in the selection of Air Force Pilots the twenty items with the largest correlations with total test score. A sample item is shown in Appendix B.

These three tests were given preliminary evaluations by administering them to a mixed input of aviation trainees and obtaining their point biserial correlations with a criterion of pass/fail in basic training. Table I shows the results. The obtained coefficients, while not very exciting, were significant at the .01 level and suggested further investigation.

Table 1

Preliminary Evaluation of Three Experimental Tests

Test	No. Succeeded	No. Failed	Biserial
Altitude Judgment	480	78	.161
Maneuvers	310	37	. 169
Instrument Comprehension	335	61	. 140

Two other experimental tests were included in the evaluation covered by this report. One was called the "Background" test (1). This is a twenty-item scale used to estimate the cultural (or socioeconomic) level of the home at the time that the respondent was in high school. The remaining experimental measure is shown in Appendix C and derives from a scale originated by P. Nelson (2). The scale lists seventeen occupations as they were ranked in prestige, and then in security by aviation trainees. The subject is asked to place the naval aviator and the naval flight officer where he feels they belong in these rankings. Four scores were obtained; the Prestige and Security scores were the numbers of the levels at which the subject placed the naval aviator. The Prestige Difference and the Security Difference scores were the differences between the ranks that the subject assigned to aviators and to NFO's.

PROCEDURE

The experimental tests were administered to aviation students during their first week at Pensacola. Two years later the data were divided into the scores of those who completed training and of those who did not. The number of students was large enough also to permit division into Aviation Officer Candidates, who are college graduates, and civilian procured naval cadets, who normally have two years of college. Selection variables and a mathematics qualifying examination, also given during the first week, were included in the analysis.

RESULTS

The correlations of the variables with each other and with a complete/attrite criterion were computed. The Wherry-Doolittle procedure was used to identify the best combination of variables with which to predict attrition, and the appropriate weights were determined. Table II shows the results for AOC's during Pre-Flight training.

The Prestige Difference score and the Instrument Comprehension score were the second and third variables chosen. The Background and Security Difference scores also added to the multiple validity; however, the amounts they added were of little practical importance.

Table III shows the prediction formula for naval cadets during the same stage of training.

This formula differs somewhat from the formula for AOC's in that the Security Score replaced the Prestige Difference, and the SAT replaced the Instrument Comprehension Test.

Tables IV and V show comparable data taken at the end of Pre-Flight School and including Pre-Flight grades and ratings in the matrix.

Table II

Prediction Formula for AOC's* During Pre-Flight Training

Variable	Cumulative Shrunker, R**	Raw Score Weight
MCT	.2390	.016
Prestige Difference	.2854	.038
Instrument Comprehension	.2925	.010
BI	.2956	.003
Background	.2958	004
Security Difference	.2961	012

^{*}N = 407

Variables not selected: Age, Education, AQT, SAT, Incoming Math, Altitude Judgment, Prestige Score, Security Score. (The matrices on which Tables II through V are based are shown in Appendix D.)

Table III

Prediction Formula for Cadets* During Pre-Flight Training

Variable	Cumulative Shrunken R	Raw Score Weight
MCT	.1802	.011
BI	.2331	.006
Security Score	.2576	.018
Age	.2721	002
Background	.2832	006
SAT	.2869	.006
AQT	.2935	003

^{*}N = 379

Variables not selected: Education, Incoming Math, Altitude Judgment: Instrument Comprehension, Prestige Score, Prestige Difference, Security Difference.

^{**}R, point biserial

Table IV

Prediction Formula for AOC's* at End of Pre-Flight Training

Variable .	Cumulative Shrunken R	Raw Score Weight
Power Plants	.2353	.007
Peer Rating	. 2844	.009
MCT	.3174	.013
Prestige Difference	.3539	.039
BI	. 3560	.002
AQT	. 3570	003
Instrument Comprehension	.3578	.007
Security Difference	.3587	012

^{*}N = 405

Variables not selected: Age, Leadership, Navigation, Incoming Math, Prestige Score, Education, Physiology, Principles of Flight, Background, Security Score, SAT, Naval Orientation, Study Skills, Altitude Judgment.

Table V

Prediction Formula for NavCads* at End of Pre-Flight Training

Variable	Cumulative Shrunken R	Raw Score Weight
Power Plants	.2548	.005
Navigation	.2870	.008
BI	.3115	.005
Peer Rating	.3301	.006
Education	.3442	039
Background	.3539	- 006
Security Score	.3630	.014
Age	.3691	002
AQT	.3762	005
MCT	.3830	.006
Physiology	.3843	.003

^{*}N = 377

Variables not selected: SAT, Principles of Flight, Altitude Judgment, Prestige Difference, Leadership, Study Skills, Instrument Comprehension, Security Difference, Naval Orientation, Incoming Math, Prestige Score.

DISCUSSION

First it should be noted that the multiple correlations shown in Tables II through V are from samples that have been severely restricted in range on the selection variables. This is so because individuals with low scores on the Flight Aptitude Rating and on the AQT were not accepted into the program. One effect of this is to limit the size of the correlations that can be obtained using these variables. But another is to increase the likelihood that other variables, not deliberately restricted by the selection process, will enter into the obtained multiple correlations. It cannot be assumed, therefore, that those experimental measures which add to the multiple correlations here would also add to them in the initial selection situation, where the variance of the present selection tests is still unrestricted.

Table VI shows which experimental tests contributed to each prediction formula. The Altitude Judgment test did not get into any of the four multiples. Thus it can be concluded that the validity shown for it in the preliminary study (Table I) duplicates variance that is present in other tests. From the intercorrelation matrices (Appendix D) it can be seen that these tests are probably the MCT and the Instrument Comprehension test.

Table VI

Contributions of Experimental Tests to Multiple Correlations

Experimental Test Variable	AOC During Pre-Flight	NavCod During Pre-Flight	AOC After Pre-Flight	NavCad After Pre-Flight
Altitude Judgment	••	***		
Instrument Comprehension	V		\checkmark	
Background	\bigcirc	⊘ *		\oslash
Prestige Score				
Prestige Difference	V		V	
Security Score		V		/
Security Difference	\bigcirc		\bigcirc	

^{*}Checkmarks in circles indicate negative Beta weights.

The Instrument Comprehension Test entered into the formulae involving AOC's but not those involving NavCads. Given the low correlations and small increments with which we are dealing, this can probably be ascribed to chance. One should investigate this test further in the primary selection situation. The same can be said of the Background Test which added somewhat to three of the multiples. It exhibited negative Beta weights, higher socioeconomic level being associated with higher attrition rates. The more valid items from this test could very easily be added to the current Biographical Inventory and revalidated under selection conditions.

The Prestige/Security Scale presents a different case, however. Three of the four scores had some validity, but completion of the tests appears to require more knowledge of the pilot/NFO career options than men in the primary selection situation would be likely to have. Thus this test should probably best be given during test time that is available during the fifth week and the results validated when new secondary selection (student prediction) formulae are developed.

CONCLUSIONS

The short-form Instrument Comprehension test should be validated with the present selection battery.

The valid items from the Background Test should be incorporated into the Biographical Inventory and revalidated under selection conditions.

The Prestige/Security Scale should be administered during the fifth week of training and the scores included in the next developmental analysis for student prediction formulae.

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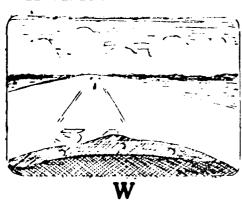
- Berkshire, J. R., and Waters, L. K., A measure of cultural background.
 NSAM-233. Pensacola, Fla.: Naval School of Aviation Medicine, 1959.
- Nelson, P. D., A note on occupational ratings of security and prestige.
 NSAM-325. Pensacola, Fla.: Naval School of Aviation Medicine, 1957.

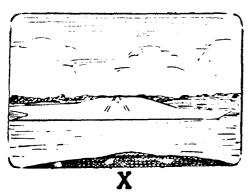
APPENDIX A

Partial Instructions and Sample Items from the Altitude Judgment Test

This is a test of your ability to judge the altitude of an aircraft from the cockpit. The pictures used in the test are drawings made from photographs taken during actual landings. Four of the pictures are identified by the letters W, X, Y, Z. Twelve are numbered. You are to compare each of the lettered pictures with each of the numbered pictures.....

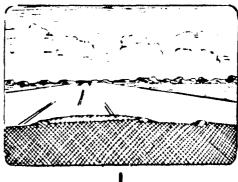
IF PLANE SEEMS HIGHER IN LETTERED PICTURE - MARK A

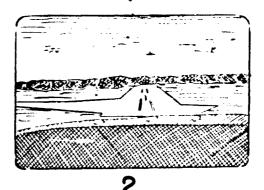


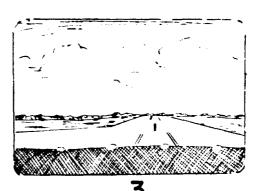


Y

IF PLANE SEEMS HIGHER IN NUMBERED PICTURE - MARK B







A-

APPENDIX B

Partial Instructions for Instrument Comprehension Test

The compass indicates the direction in which the plane is headed. Note these sample readings:









HEADED NORTH

HEADED WEST

HEADED NORTHWEST HEADED NORTH OF NW

The artificial harizon has two functions. First, it shows whether the plane is climbing, diving, or flying level. Second, it indicates the amount and direction of bank of the plane.

When climbing, the horizon lines appear below the small plane as in dial 1. When diving, the horizon lines appear above the small plane as in dial 2. When flying level, the horizon

lines are even with the small plane.

The arrowhead in the dial registers the number of degrees of of zero as in dial 3. A right bank is read in number of

bank. A left bank is read in number of degrees to the right degrees to the left of zero as in dial 4.

When the plane is both banked and climbing, the dial appears as in dial 5. When the plane is both banked and diving,





3. LEFT BANK





S. LEFT BANK, CLIMBING

6. RIGHT BANK. DIVING

Now examine the dial readings in problem 8. Then select the correct position of the plane.

PROBLEM B

the dial appears as in dial 6.



.....





COMPASS







Ε

В D C

According to the dials, the plane is banked left, flying level, and is headed south. (B) is the correct answer, because at position (B) the plane is banked left, flying level, and is headed south.

In each problem choose the position of the plane that is correct for the dial readings; then blacken the space on the answer sheet which corresponds to the answer you select. If you are not sure which is the correct answer, make the best guess you can. Work rapidly and carefully until you are told to stop. When you finish one page, go on to the next.

You will have 5 minutes to complete the 20 items. If you finish before time is called, you may go back over your work.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO.

APPENDIX C

NAM	E			CLASS NO.	(DATE	
	LAST	FIRST	MIDDLE				
AOC		N/C	M/C	Al	NAO	OI	

The occupations below were ranked by 350 naval aviation trainees. Note that the left-hand list is ranked from top to bottom according to "PRESTIGE," while the right-hand list is ranked in terms of "CAREER SECURITY." Compare the prestige of the Naval or Marine Aviator with that of the occupations in the left-hand list and write in the letters NA at that point in the list where you feel the Naval or Marine Aviator fits. Do the same for the Naval Aviation Officer (non-pilot)-NAO. Then, in the right-hand list compare the NA and NAO career security with that of the occupations listed and write each into the appropriate space.

PRESTIGE

CAREER SECURITY

Physician	17	Physician
Scientist	16	Engineer
Minister	15	Scientist
Lawyer	14	Minister
Engineer	13	Banker
College Professor	12	College Professor
Banker	11	Lawyer
Architect	10	Architect
Politician	9	News Columnist
Businessman	8	Accountant
News Columnist	7	Businessman
Radio - TV Announcer	6	Personnel Director
Personnel Director	5	Farmer
Sales Promotion	4	High School Coach
High School Coach	3	Radio - TV Announcer
Accountant	2	Sales Promotion
Farmer		Politician

BOTTOM

BOTTOM

APPENDIX D

Intercorrelation Matrix -- AOC's* During Pre-Flight Training

		00	005	8	904	905	8	007	80	8	010	110	012	013	014	015
Age Education AQT MCT SAT BI Mathematics Background Altitude Judgment Instrument Comprehension Prestige Score Prestige Difference Security Score Security Difference	01 03 04 05 07 07 07 11 12 13 13		251	019	086 028 403	-027 -060 170 054	001 010 073 073 -0%	-037 075 360 080 080 -033	019 019 065 065 065 058 058	087 202 202 286 179 035 090	075 046 276 283 143 143 289 289	031 -116 -116 -126 -026 -027 -027 -027 -027	983 971 971 971 971 971 971 971 971 971 971	045 022 010 010 018 020 020 076	040 003 003 054 054 055 330 330 355	000 000 000 000 000 000 000 000 000 00

*N = 407. A coefficient of .115 is significant at the .01 level.

APPENDIX D

Intercorrelation Matrix -- Cadets* During Pre-Flight Training

	8	ω 100	005 (903	8	98	8	200	808	60	010	110	012	013	014	015
Age	10	7)- 982		019	051	059	-103	-015	060	098	-031	-059	055	020	080
Education	05	Í		124	8	S	-022	88	027	021	83	88	80	-0	8	93
AQT	63				371	225	80-	8	848	161	<u>₹</u>	9	8	8	-018	-017
MCT	z					8	<u>×</u>	292	-063	244	242	-070	-016	8	024	187
SAT	92						8	083	9	230	266	025	983	017	-015	680
18	%							-109	<u>%</u>	-032	800	<u>₹</u>	<u>-</u>	8	3	179
Mathematics	0,								-088	8	83	8	B	8	-032	057
Background	80									021	055	<u>-</u>	113	8	8	890-
Altitude Judgment	60										<u>3</u>	3 99	-012	023	g	8
Instrument Comprehension	01											-013	145	022	960	082
Prestige Score													355	8	960	600
Prestige Difference	12													910	267	-029
Security Score	13														452	121
Security Difference	14															63
Complete/Attrite	15															

*N = 379. A coefficient of .120 is significant at the .01 level.

APPENDIX D

Intercorrelation Matrix -- AOC's* After Pre-Flight Training

		001 002 003 004 005 006 007 008 009 010 011 012 013 014 015 016 017 018 019 020 021 022 0	023
Age	5	250-048 (33-026 099-121-010-000-096 012-054-010 036-037-008 087 072 024-086 040 040-004	ا ا
Education	05	027 -060 -063 -106 034 003 -145 -013 -019 -099 007 075 020 090 046 -119 -096 021 003	3 5
AQT	ဗ	418 260 350 430 419 348 544 059 199 274-115-089-061-139	074
MCT	8	115 354 405 157 313 402 045 355 071 278 282-063-018 001-097	237
SAT	9	76 134 033 057 196 099 090 081 -045 181 332 -043 -024 -112 -037	8
E C	%	24-034 110 033 142 159 070 016 053	101
Leadership	0	148 114 030 061 113-095-049-040-078	8
Peer Rating	80	52 212 017 060 163-050-088-062 004	216
Physiology	60	02 287-001 094 222-036-004 035-097	89
Power Plants	9	24 280 -076 060 158 -027 035 038 -074 VA	240
Naval Orientation	=	289 105 055 124 117-124-058-078-113	052
Navigation	12	78 462-036 120 285-090-068-030-061	172
Principles of Flight	13	-064 098 175-102-047-041-133	183
Study Skills	14	078 022 100-067-006-077-033	050
Mathematics	15	072 213 004 030 006-035	120
Background	9	050 -018 -018 -089 -037	021
Altitude Judgment	17	299-031-059-031 041	076
Instrument Comprehension	8	049 056 014 056 1	15.
Prestige Score	6	341 315 111	030
Prestige Difference	20	021 330	133
Security Score	51	357	020
Security Difference	22		ê
Complete/Attrite	23		3

 * N = 405. A coefficient of .116 is significant of the .01 level.

APPENDIX D

Intercorrelation Matrix -- Coders* After Pre-Flight Training

Age Education 02 873-057 020 AQT AQT AQT ACT 03 373-005 AQT ACT 04 SAT 05 BI Leadership Peer Rating Physiology Power Plants 10 Navy Orientation Principles of Flight Study Skills Adtitude Judament 17	7 020 058 060 037 159-083-016 016-028-026 019-104-013 093 103-035-061 060 023-076 3-005 042-022 179 086 033-029 131 062 048 141 086 026 020 055-005-029-014-007-097 373 223-097 343 122 308 159 349 326 328 377 480 050 161 165-040 006 008-020-022 179 133 135 126 295 460 116 217 440 119 293-065 242 240-068-016 003 022 186 -001 058 141 165 013 022 145 087 052 086 015 226 258 038 069 003-026 072 -003-029-024 225-017 048 175 001-108 183-034 206 042-011-004 043 180 137 268 229 429 193 333 318 185 020 079 072-068-006 028-047 003 045 120 105 226 167 101 165 040 033 133-075-031 070 042 168 345 329 253 379 192 222-059 170 166-018 066 006-026 138 202 356 605 145 283-049 026 055-013 049-007-005 260 194 376 399 191 015 013 011 033 102 107-046 086
00 00 00 00 00 00 00 00 00 00 00 00 00	042-022 179 086 033-029 131 062 048 141 086 026 026 022 33-097 343 122 308 159 349 326 328 377 480 050 161 179 133 125 126 295 460 116 217 440 119 293-065 245 -001 058 141 165 013 022 145 087 052 086 015 226 -003 -029-024 225-017 048 175 001-108 183-034 137 268 229 429 193 333 318 185 020 075 045 120 105 226 167 101 165 040 033 345 329 253 379 192 222-059 176 202 356 605 145 283-049 026 194 376 399 191 015 015
03 00 00 00 00 00 00 00 00 00 00 00 00 0	223-097 343 122 308 159 349 326 328 377 487 050 161 179 133 125 126 295 460 116 217 447 119 293-065 245 -001 058 141 165 013 022 145 087 052 086 015 226 -003 -029-024 225-017 048 175 001-108 183-034 137 268 229 429 193 333 318 185 020 075 045 120 105 226 167 101 165 040 033 345 329 253 379 192 222-059 170 184 376 399 191 015 015
4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	179 133 125 295 460 116 217 440 119 293 -065 245 -001 058 141 165 013 022 145 087 052 086 015 226 -003 -029 -024 225 -017 048 175 001 -108 183 -034 137 268 229 429 193 333 318 185 020 075 045 120 105 226 167 101 165 040 033 345 329 253 379 192 222 -059 170 184 345 329 253 379 192 222 -059 170 184 376 399 191 015 015
	058 141 165 013 022 145 087 052 086 015 226 003-029-024 225-017 048 175 001-108 183-034 137 268 229 429 193 333 318 185 020 075 045 120 105 226 167 101 165 040 033 345 329 253 379 192 222-059 176 202 356 605 145 283-049 026 194 376 399 191 015 013
	003-029-024 225-017 048 175 001-108 183-034 137 268 229 429 193 333 318 185 020 075 045 120 105 226 167 101 165 040 033 345 329 253 379 192 222-059 170 202 356 605 145 283-049 026 194 376 379 191 015 015
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	105 226 167 101 165 040 035 329 253 379 192 222-059 170 202 356 605 145 283-049 026 194 376 399 191 015 015
	329 253 3.79 192 222-059 170 202 356 605 145 283-049 026 194 376 399 191 015 013
Power Plants 10 Navy Orientation 11 Navigation 12 Principles of Flight 13 Study Skills 14 Mathematics 15 Bockground 16 Altitude Judament 17	356 605 145 283 - 049 026 194 376 399 191 015 013
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Principles of Flight 13 Study Skills 14 Mathematics 15 Background 16 Altitude Judament 17	091 420-001 172
Study Skills 14 Mathematics 15 Background 16 Altitude Judament 17	384-076 086
Mathematics 15 Background 16 Altitude Judament 17	8
Background 16 Altitude Judament 17	60
Altitude Judament 17	018 050-007 115 001
	160 -064 -010 017
Instrument Comprehension 18	-005 149 011
Prestige Score 19	353 202
Prestige Difference 20	020
Security Score 21	
Security Difference 22	
Complete/Attrite 23	

*N = 377. A coefficient of .120 is significant at the .01 level.

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